Distribution, habitat and conservation status of the Eastern Pygmy-possum *Cercartetus nanus* in Queensland

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ABSTRACT

Reliable modern records of the Eastern Pygmy-possum *Cercartetus nanus* in Queensland were collated from various sources (including databases and previous reports) and a map of potential *C. nanus* habitat was generated based on an analysis of regional ecosystems and expert decision rules. Modern records of *C. nanus* (collected between 1936 and 2002) are confined to the far south-east of the State, from or adjacent to Lamington and Mt Barney National Parks. Only 13 modern records exist and all but one are from or above 750 m elevation. Attention is also drawn to the existence of Late Pleistocene fossil records of *C. nanus* from Russenden Cave, Viator Hill, in south-east Queensland, which may suggest that a long-term range contraction has occurred. Currently the status of *C. nanus* is officially 'least concern' under the Queensland *Nature Conservation (Wildlife) Regulation 1994*. A reappraisal of the species' conservation status in this State was undertaken using the available evidence and the World Conservation Union (IUCN) criteria. We found that *C. nanus* has a highly restricted distribution in Queensland and is probably subject to threatening processes. Its apparent preference for high elevation sites also suggests that it may be adversely affected by future climate change. Hence, we recommend that the species be nominated for listing as 'endangered' in Queensland. Targeted field studies are needed to more fully document the distribution and abundance of *C. nanus* in this extreme northern part of its range.

Key words: *Cercartetus nanus,* pygmy-possum, distribution, habitat preferences, fossil, conservation status, threatened species, Queensland, Lamington National Park, Mt Barney National Park

Introduction

The Eastern Pygmy-possum *Cercartetus nanus* is a small (15-43 g), arboreal marsupial that is widespread in New South Wales (NSW) (Bowen and Goldingay 2000), Victoria (Harris and Goldingay 2005a) and Tasmania (Munks et al. 2004), but has a restricted distribution in South Australia (SA) (van Weenen and Harris 2006) and in Queensland (Eyre 2004). A few localities and a small number of specimens from the far south-east of Queensland (Qld) represent the northern extremity of the species' known geographic range (Van Dyck and Longmore 1991; Eyre 2004). Despite this, the species is classed as 'least concern' under the Qld *Nature Conservation Act 1992*. This situation arises because the *Nature Conservation (Wildlife) Regulation 1994* (subordinate legislation to the *Nature Conservation Act 1992*) lists all vertebrates 'least concern' unless they are listed as 'extinct in the wild', 'endangered', 'vulnerable', 'rare' or 'near threatened'. There appears to be an incongruity between the legal status of *C. nanus* and recognition that the species is highly restricted in this State. Eyre (2004) suggested that the conservation status of *C. nanus* requires further consideration due to its limited distribution. The aims of this study with respect to the Qld population were to: i) review all available information on the distribution and abundance of *C. nanus*, ii) identify and map all potential habitat of *C. nanus*, and iii) use the IUCN threatened species criteria (Species Survival Commission 2001; IUCN 2003) to reassess the species' status.

Methods

Locality records for *C. nanus* were obtained from the WildNet database (at 12 October 2005) maintained by the Qld Environmental Protection Agency (EPA). Details of specimens held in the Qld Museum (QM) were also obtained (at 17 March 2005) and matched against the WildNet data to ensure no duplication of records. Northern NSW records of *C. nanus* were obtained from the Atlas of NSW Wildlife (at 7 June 2005), maintained by the NSW Department of Environment and Conservation, to determine the elevational range of *C. nanus* in areas adjoining Qld (see below). A search of journal literature on *C. nanus* was undertaken to locate any previously overlooked records, and enquiries regarding any unpublished sightings were also made with EPA staff, Qld Parks and Wildlife Service (QPWS) staff at several national park (NP) offices, including Lamington NP. Similar enquiries were made with University of Queensland zoologists and naturalists at or formerly associated with O'Reilly's Rainforest Guesthouse and Binna Burra Mountain Lodge. Although descriptions of several records have been published previously, it was fundamental to our investigation that we provide a written review of the circumstances surrounding these early records in order to make clear the relationship between various database entries and particular specimen or literature records. Also, we considered it important to compile a detailed account of a record that has hitherto only been reported in Brisbane newspapers.

Guidelines for listing protected wildlife under the *Nature Conservation Act 1992* were referred to for determination of an appropriate IUCN category using the Red List Criteria (Species Survival Commission 2001; IUCN 2003). These state that the "best available evidence indicates that" a "threatened" species satisfies any of five criteria demonstrating "a very high risk of extinction in the wild" (see Species Survival Commission 2001; IUCN 2003). These criteria are used by the Scientific Advisory Committee (SAC; established under the Qld *Nature Conservation Act 1992*) to determine whether wildlife in Qld should be listed as 'extinct in the wild', 'endangered', 'vulnerable', 'rare' or 'near threatened'.

Geographic data were stored and mapped using an ArcInfo Geographic Information System (GIS). To obtain an area estimate of potential *C. nanus* habitat in Qld, a habitat suitability map was generated using an expert-derived rule-set and 1:50,000 scale regional ecosystem mapping (EPA 2004). The map was produced for areas above 750 m elevation adjacent to the Qld-NSW border. This elevation threshold was selected since all but one of the modern *C. nanus* records for Qld and north-east NSW are at or above this elevation (Appendix 1). The aberrant record, a specimen from the Running Creek valley, was from approximately 359 m elevation. It was not considered during the habitat suitability mapping exercise as the locality of the record was regarded as imprecise. Due to the steep terrain in the vicinity of the record, a relatively small error in locality corresponds with a large variation in elevation. Within the 750 m envelope, regional ecosystem (REs; defined as vegetation communities consistently associated with a particular combination of geology, landform and soil; Sattler and Williams 1999) in Qld were selected within the GIS. The REs were classed as having 'High', 'Medium' or 'Low' suitability for *C. nanus* based on local knowledge of the habitats present at the point localities of Qld *C. nanus* records (Eyre 2004; G. Krieger unpubl. data, QPWS; pers. obs. of authors), as well as the range of habitats occupied by *C. nanus* in NSW, Victoria and SA (Bowen and Goldingay 2000; Harris 2005; Harris and Goldingay 2005a; Harris 2006; van Weenen and Harris 2006; see also Appendix 2). In particular, we were guided by the fact that records in northern NSW and Qld are closely associated with rainforest and adjacent wet sclerophyll forest and those in northern NSW with *Banksia* spp. so these attributes (especially a shrubby understorey or midstorey) were favoured over the presence of *Eucalyptus* spp *per se*. Therefore, an RE was identified as having: i) 'High' *C. nanus* habitat suitability if there were known, reliable *C. nanus* records from that RE; ii) 'Medium' *C. nanus* habitat suitability if there were no known records from the RE, but it was floristically and structurally similar to REs classed as 'High'; or iii) 'Low' *C. nanus* habitat suitability for remaining REs within the >750 m envelope. Various minimum convex polygons were obtained using Hawth's tools (Beyer 2004) and ArcGIS™ to derive area of occupancy and extent of occurrence measures for *C. nanus* in Qld.

Results

Locality records

Cercartetus nanus appears to have been first located in southern Qld prior to January 1936 by Molly O'Reilly, a short distance from O'Reilly's Rainforest Guesthouse, on Roberts Plateau within Lamington NP (O'Reilly 1941 p.21; Wakefield 1970). The specimen was provided to the QM on 7 January 1936 and is registered J5861 (Wakefield 1970; Appendix 1). However, in providing a general description of the fauna of Lamington NP, Young (1937) states that *C. nanus* "is found occasionally living in small hollow pipes in trees". This suggests either that observations of *C. nanus* were made prior to the collection of the specimen by Molly O'Reilly or that his account was based on Molly O'Reilly's specimen and the circumstances of its discovery. Due to the lack of data accompanying Young's (1937) account, no specific record can be attributed to his observation. A second animal was found nearby on the Main Border Track by Vince Preston in January 1966 (Fleay, 1966a). This specimen was provided to the QM on 9 February 1966 and registered as J13580. However, it was mistakenly reported in a newspaper article by David Fleay as being *C. caudatus*, the Long-tailed Pygmy-possum of north-east Queensland and Papua New Guinea (Fleay 1966a; Wakefield 1970; Flannery 1994).

The third record for Qld came just two months later on 31 March 1966 when an adult female was recovered from the stomach of a Rough-scaled Snake *Tropidechis carinatus* that had been killed after biting a Forestry Department worker at Nagarigoon Camp, Lamington NP, 3.0 km south-east of Binna Burra Mountain Lodge (Anon. 1966; Fleay 1966b; P. Ogilvie pers. comm. 2005, EPA). The discovery was only made after Peter Ogilvie (then of the Forestry Department) had taken the snake to David Fleay for confirmation of its identity. The distinct bulge in the animal prompted an examination of the stomach contents. It was surmised that the pygmy-possum had been swallowed only about two hours before the snake's death; also found in the stomach were the partly digested remains of an immature rat, possibly the Bush Rat *Rattus fuscipes*, swallowed some 12 hours before the snake was killed (Fleay 1966b). The *C. nanus* specimen was retained in a Forestry Department collection but was subsequently lost (P. Ogilvie in litt. 2005, EPA).

A fourth *C. nanus* individual from near O'Reilly's Rainforest Guesthouse was found by Peter O'Reilly in late January 1977. It was discovered in a torpid state, curled up in a ball on the ground on the Lamington NP Road, 1.5 km from the Guesthouse, and was subsequently kept in captivity by Brian Mackness, then of the Qld National Parks and Wildlife Service (P. O'Reilly pers. comm. 2005; Appendix 1). It was this *C. nanus* individual that provided the example of pseudoparasitism by a land planarian subsequently described by Winsor (1980). The specimen was reportedly 'mislaid' and so never forwarded to the QM for preservation (P. O'Reilly pers. comm. 2005; S. Van Dyck pers. comm. 2005, QM).

It is also noted that two records exist from O'Reilly's Rainforest Guesthouse land, adjacent to Lamington NP: *C. nanus* was once spotlighted by Tim O'Reilly about 2 m above ground on a section of the Wishing Tree Track around 1990, and a separate observation was made by Ed Meyer and Ben Manning along the track to the Tree Top Walk in November 1994 (E. Meyer, pers. comm. 2005, University of Qld; T. O'Reilly, pers. comm. 2005, O'Reilly's Rainforest Guesthouse; Appendix 1). The most recent record is of a dead juvenile individual found on the Lyrebird Lookout Track (in Lamington NP) by staff of O'Reilly's Rainforest Guesthouse in 2002 and forwarded to the QM (JM15007; Appendix 1).

The QM database contains locality data for five other modern Qld records – four from or adjacent to Lamington NP and one from Mt Barney NP (Appendix 1). The WildNet database contains 11 *C. nanus* records, of which all but one refer to QM specimens or records already detailed above (including Young 1937). The remaining record is a second individual from Mt Barney NP (Appendix 1). WildNet also includes fossil records (see below). Prior to this assessment being undertaken, WildNet contained a number of duplicate or erroneous records of *C. nanus* sourced from Plowman (1986), Oliver (1987) and an earlier departmental database but these errors have now been corrected. All known reliable modern records are from or adjacent to Lamington NP and Mt Barney NP (Fig. 1), localities separated by approximately 38 km. The records from the Lamington area comprise 11 sites within a radius of 11 km in or adjoining the NP. The two sites in Mt Barney NP are located less than 6 km apart.

Cercartetus nanus is also recorded as a fossil from the Late Pleistocene assemblage at Bone Chamber, Russenden Cave, on Viator Hill, near Texas (Archer 1978a). From the 0-20 cm layer of the deposit at least two *C. nanus* dentaries were present (see Appendix 1). Archer (1978a) compared these specimens (F8207 and F8209) with the dentition of a modern animal collected from Lamington NP (J13580) and found them to be "virtually identical". A third specimen, F9462, was somewhat larger, but lacked teeth and so assignment to *C. nanus* was done so only cautiously (see Archer 1978a). Hence, we have not accepted F9462 as definitely *C. nanus*, and as such it is not included with the reliable records listed in Appendix 1. It is probable that specimen F9462 is *C. nanus* but, if not, it is an undescribed *Cercartetus* sp., possibly conspecific with other extinct and also presently undescribed *Cercartetus*-like species (see Tedford and Kemp 1998; Crosby *et al.* 2004; Hocknull 2005). We also note that some unidentified bulk locality material from Russenden Cave is still in storage at the QM.

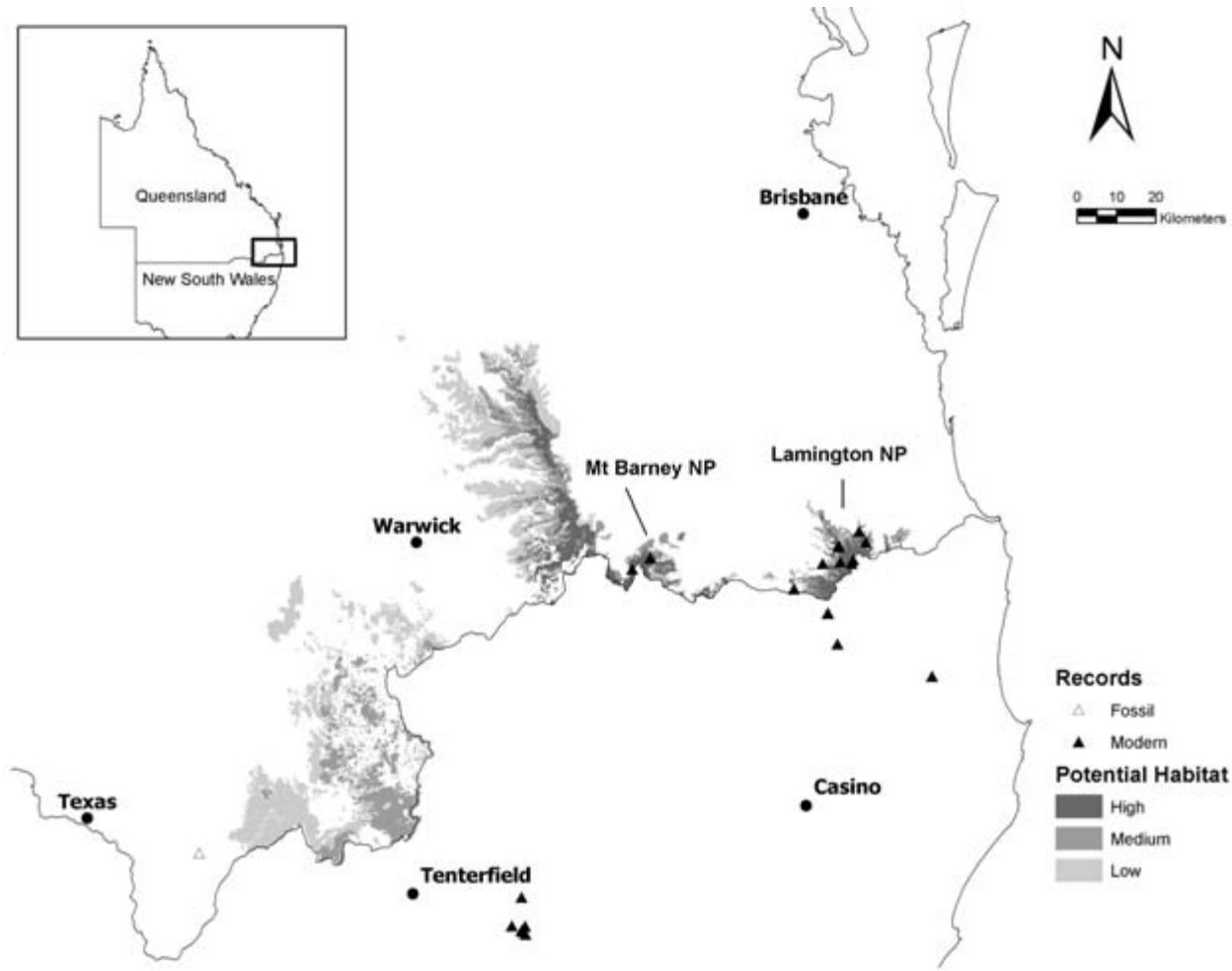

Figure 1. Distribution of known *Cercartetus nanus* records and expert-derived habitat mapping in Queensland.

Habitat

Information about *C. nanus* habitat in south-east Qld is limited by the number of available records. Of the 11 documented occurrences of *C. nanus* in the Lamington NP area, eight have sufficiently accurate locational data to enable the associated vegetation community to be determined. Five were from very tall complex notophyll ('cool subtropical') closed forest, one from a mosaic of this community and tall simple to complex microphyll closed forest, and another was from tall simple microphyll ('cool temperate') closed forest dominated by *Quintinia* sp. (vegetation mapping in Oliver 1987; A. Pollock unpubl. data, EPA). The specimen removed from the stomach of the Rough-scaled Snake killed at Nagarigoon Camp was collected in New England Ash *Eucalyptus campanulata* extremely tall open forest close to an ecotone with Coachwood *Ceratopetalum apetalum* tall simple microphyll closed forest. It is impossible to determine whether the *C. nanus* was utilising these communities when it fell prey to the snake.

Descriptions of the two *C. nanus* capture sites in Mt Barney NP (G. Krieger pers. comm. 2005, QPWS) were very tall open forest of *E. campanulata*, Tallowwood *E. microcorys*, Sydney Blue Gum *E. saligna* and Brush Box *Lophostemon confertus* (Site A, 1.5km SW of Mt Ballow) and very tall open forest of *L. confertus*, Flooded Gum *E. grandis*, *E. saligna* and *E. microcorys* with *Banksia conferta* midstorey (Site B, 0.6 km NW of Montserrat Lookout), in both cases adjoining extensive areas of tall closed forest. A recent inspection of the trapping location at Site B by one of us (MTM) revealed that only scattered *Banksia conferta* was evident in a sparse midstorey, although a dense *Banksia* shrub layer was present only 200 m away.

Habitat suitability mapping

Of the 67 regional ecosystem types mapped above 750 m elevation in south-east Qld (246,232 ha) five were classed as having 'High', 17 classed as having 'Medium' and the remainder were classed as having 'Low' potential habitat suitability for *C. nanus* (Fig. 1, Appendix 2). Corresponding areas were approximately 383 km^2 (38,325 ha) for 'High' habitat suitability, 806 km^2 (80,612 ha) for 'Medium' habitat suitability and 1,273 km^2 (127,295 ha) for 'Low' habitat suitability. Far northern NSW records are from Forest Tops and Bar Mountain in Border Ranges NP, Mt Jerusalem NP (formerly Nullum State Forest), Timbarra and Poverty Point. The nearest NSW record is 11 km from a known Qld locality. All the *C. nanus* records for Qld lie within the NSW North Coast Bioregion, an essentially NSW bioregion, a small part of which is found in Qld and encompasses the McPherson Range and an extension north along the Great Dividing (Main) Range (Thackway and Cresswell 1995).

Conservation status

The most appropriate data for assessing the conservation status of *C. nanus* in Qld relate to the species' geographic range, i.e. IUCN criterion B. A minimum convex polygon drawn to encompass all known, modern *C. nanus* records in Qld (Fig. 2) has an area of 47,240 ha (472 km^2). This

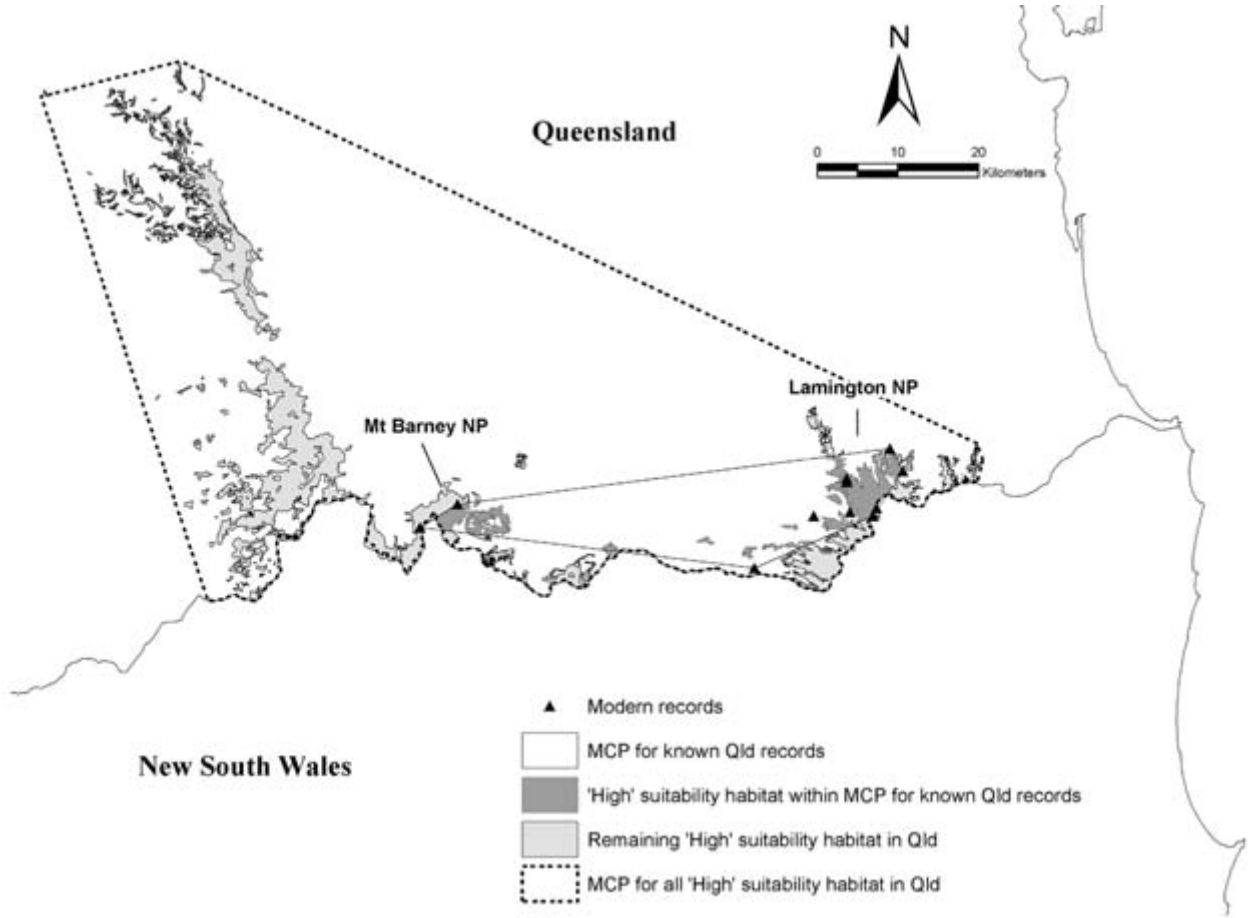

Figure 2. Measures of known and potential extent of occurrence and area of occupancy of *Cercartetus nanus* in Queensland. Abbreviations: NP = National Park; MCP = minimum convex polygon.

value, corresponding to the 'extent of occurrence' of the species in Qld, is well below the threshold of 5000 km^2 stipulated under criterion B1 for the 'endangered' category. The area of predicted 'High' suitability habitat occurring within this minimum convex polygon provides a useful estimate of the species' 'area of occupancy' in Qld. From GIS calculations, this area was determined to be 6270 ha (63 km^2), a value well below the threshold (500 km^2) stipulated under criterion B2 for 'endangered' taxa (Fig. 2).

The above geographic range estimates were both based on known *C. nanus* records, however, even if the species was found to occur throughout all areas of what we predict to be 'High' suitability habitat in Qld (Fig. 1), it would still meet the criteria for endangered status. For a potential or inferred extent of occurrence measurement, a minimum convex polygon encompassing all habitats mapped as being of 'High' suitability has an area of 489,000 ha (4,890 km^2), i.e. less than the 5000 km^2 threshold given under criterion B1 (Fig. 2). This value is actually a gross overestimate because it incorporates extensive tracts of unsuitable, lowland habitat to the north of the McPherson Range and east of the Main Range that, under IUCN guidelines, can reasonably be excluded when performing range estimations. In terms of a potential or inferred area of occupancy of *C. nanus* in south-east Qld, the value of 383 km^2 for 'High' suitability habitat derived from our RE mapping is still beneath the 500 km^2 threshold stipulated under IUCN criterion B2 (Fig. 2).

To qualify as 'endangered' under criteria B1 or B2 also requires estimates indicating a species exists at no more than five locations and that a continuing decline in population or geographic range will occur. The IUCN defines 'location' as "a geographically or ecologically distinct area in which a single threatening event can rapidly affect all individuals of the taxon present". The small distance between sites in both Lamington and Mt Barney NPs suggests that currently *C. nanus* is known from only two locations in Qld. Predation by feral cats and foxes is suspected to pose a threat to *C. nanus* in north-east NSW (Gilmore and Parnaby 1994). While foxes are either absent or in low numbers at high elevations within the range of *C. nanus* in south-east Qld, the feral cat population in these areas is considerable (pers. obs. of authors). As a consequence, feral predation may also be impacting on Qld populations of *C. nanus* (Eyre 2004). A continuing decline in the number of individuals is inferred from the fact that just a single record has been obtained in the last 10 years whereas in the previous 20 years there were about six records. Furthermore, there has been greater survey effort in the last 10 years likely to detect this species (see below). *Cercartetus nanus* is apparently restricted to cool, moist forests on the tops of mountain ranges in Qld, which suggests that it will be particularly susceptible to the future effects of climate change. For these reasons, it is projected that *C. nanus* will decline over time in its geographic range, quality of habitat and population size. Therefore, the evidence currently available for *C. nanus* in Qld indicates that a listing of 'endangered' under criteria B1 and B2 is justified. Summarised from the IUCN document, the relevant criteria for this nomination are: EN B1ab(i,ii,iii ,v)+2ab(i,ii,iii,v), C2a(i).

Unfortunately, no additional support for such a listing could be obtained by assessing *C. nanus* against the remaining IUCN criteria. The total population size of the species in Qld is likely to be below the threshold of 2500 mature individuals, but available information does not allow estimation of the magnitude of any past or projected population declines, an evaluation of the population structure, or a confident determination of whether the total population is below 250 mature individuals in Lamington and Mt Barney NPs. No PVA has been conducted on this species, precluding a nomination based on modeling that predicts the time until extinction.

Discussion

Distribution

Information on the distribution of *C. nanus* in Qld is scarce, with the small number of records indicating the species is neither abundant nor widespread. *Cercartetus nanus* has long been known to be present in Lamington NP, the southern edge of which is the Qld-NSW border (O'Reilly 1941 p.21; Wakefield 1970; Churchett 1982), but there are only 11 reliable records from this locality. The species' absence from more northerly areas has led to the suggestion that its occurrence in Qld may be nothing more than a "spill-over" from NSW (Van Dyck and Longmore 1991). While it may be a reasonable preliminary hypothesis that the Qld distribution is of quite recent origin, the discovery of fossil *C. nanus* at the Late Pleistocene deposits at Viator Hill would suggest that a "spill-over" from NSW is not a recent event and probably occurred >10,000 years ago. Further study of this fossil material could ascertain whether more specimens of *C. nanus* exist and establish age limits for the deposit. The fossil records from Russenden Cave (Fig. 1) are approximately 133 km from where living examples of the species have been found in modern times. This represents the western extremity of the species' known prehistoric range in Qld, and, because modern populations have not been found in the Texas Caves area (Archer 1978b), it may suggest a long-term range contraction has occurred in Qld.

Cercartetus nanus has the most restricted distribution in Qld of all of Qld's possum and glider species (Eyre 2004), and for this reason it was listed as a priority species during the South East Qld Forest Agreement process. Nagarigoon Camp near Binna Burra, at the north-eastern edge of Lamington NP, currently represents the northern limit of its known geographic range in Australia. Records from Mt Barney NP during 1994 and 1995 significantly extended the known modern distribution of *C. nanus* west along the State border (Eyre 2004). However, it is not known whether populations from Lamington and Mt Barney NPs are contiguous or disjunct, although those from Lamington NP are probably contiguous with at least some populations in NSW. All modern Qld *C. nanus* records are from the NSW North Coast Bioregion. This suggests a basis for the highly restricted nature of the distribution in Qld and highlights the 'edge of range' nature of the Qld populations.

Our habitat suitability mapping has identified areas that should be targeted in further surveys for this species in Qld. A very broad area to the north-west of Mt Barney, representing high elevation sections of the Main Range, has potentially high habitat suitability for *C. nanus* (Fig. 1). Given that the most effective survey methods for this species have been identified (Bowen and Goldingay 2000; Bladon *et al.* 2002; Harris and Goldingay 2005a,b), it should in theory be straightforward to conduct such surveys and to evaluate the results, although difficulties in accessing some locations may make field work challenging. Surveys should also be conducted at known locations in north-east NSW where records have been obtained more recently than in Qld, particularly where multiple records occur (e.g. Vernes *et al.* 2006). This will provide a useful basis for comparison with surveys in Qld and allow an assessment of appropriate survey effort. If such surveys are conducted over a broad area, they may also provide a better understanding of habitat preferences and elevational limits.

Detectability

Cercartetus nanus was not detected during the Comprehensive Regional Assessment systematic surveys conducted in 1997 across the Southeast Qld Bioregion, despite a total of 15 days' survey effort (Elliott trapping, pitfall trapping, spotlighting, hair tubes, predator scat analysis) in potential habitat in the Forest Reserves (formerly State Forests) of Goomburra (5 day survey), Numinbah (5 day survey) and Emu Vale in the Main Range area (5 day survey) (Eyre *et al.* 1998). Eyre (2004) noted that these surveys were undertaken during winter and spring, when the species' activity is limited and more time is spent in torpor (Geiser 1993; Bladon *et al.* 2002). Nevertheless, the species has been detected in winter and spring, albeit less frequently, in more southern areas of its range (Ward 1990; Harris and Goldingay 2005a; J.M. Harris unpubl. data).

Further emphasising the poor detection rate of *C. nanus* during fauna surveys in Qld, prolonged and extensive survey effort in the vicinity of O'Reilly's Rainforest Guesthouse (adjacent to Lamington NP), the known location of five opportunistic records (Appendix 1), has failed to record the species. For example, no captures or sightings of *C. nanus* were made in notophyll closed forest during field trips conducted annually over a 40-year period as part of a University of Qld Rainforest Ecology course despite a survey effort amounting to several thousand trap-nights and an estimated total exceeding 100 spotlight-hours (Kikkawa in Plowman 1986; A. Goldizen pers. comm. 2005, UQ). In addition, *C. nanus* has not been captured during 22,650 Elliott trap-nights conducted by one of us (ICG) in closed forest and adjacent eucalypt open forest at this same locality since 1994. Furthermore, significant survey effort in potential habitat at other sites within the known or predicted Qld distribution of *C. nanus* (Mt Gipps, Richmond Gap: 1950 Elliott trap-nights; Gambubal Forest Reserve: 3700 Elliott trap-nights; Girraween NP: 2000 Elliott trap-nights and 48 pitfall trap-nights) has not revealed the presence of the species (Lehmann 2002; I.C. Gynther unpubl. data). Bowen and Goldingay (2000) reported capture rates for *C. nanus* of 0.04 per 100 Elliott trap-nights and 0.06 per 100 pitfall trap-nights for fauna studies conducted in NSW. Harris and Goldingay (2005a) reported rates of 0.14 (Elliott traps), 0.29 (pitfall traps) for fauna studies in Victoria. Thus, data from three States support the contention that the species is difficult to detect and that populations are possibly small and isolated.

Although the information presented above lends support to previous conclusions regarding the difficulty with which *C. nanus* is detected, it has been demonstrated that targeted trapping and/or nest-boxes in certain areas have resulted in a sufficient number of captures to allow population studies (Turner 1986; Ward 1990; Bladon *et al.* 2002; Harris and Goldingay 2005b). However, in Lamington NP, 33 nest-boxes were installed by one of us (ICG) in June 2004 to target *C. nanus* but no animals or their characteristic nesting material were found within the boxes when checked in October 2004 or January 2005. Thirteen of these boxes were installed at Snake Ridge in open forest (with midstorey containing *Banksia*) close to a rainforest ecotone, and the remainder in complex notophyll closed forest divided between the Wishing Tree Track near O'Reilly's Rainforest Guesthouse and the Lyrebird Lookout Track, both known *C. nanus* locations (Appendix 1). Nest-box surveys probably provide the best and most cost-effective option for conducting further surveys for *C. nanus* at a range of sites (see Beyer and Goldingay 2006).

Habitat

Throughout its range *C. nanus* inhabits a variety of vegetation communities from heathland to rainforest. In southern Australia, *Banksia* woodland may be preferred over other vegetation alliances because it allows the species to attain high population densities (Ward 1990; Turner and Ward 1995; Bowen and Goldingay 2000; Harris and Goldingay 2005a). However, the availability of specific food resources such as nectar, pollen, invertebrates, seeds and fruits (Huang *et al.* 1986; Dickman and Happold 1988; Goldingay *et al.* 1991; van Tets and Whelan 1997) and the availability of habitat with sufficient understorey density (Wakefield 1963; Harris and Goldingay 2005a) are likely to be major determinants of the species' distribution and abundance throughout its range.

Information from the two capture sites in Mt Barney NP, together with vegetation communities associated with Lamington *C. nanus* records, allowed Eyre (2004) to propose that *C. nanus* may be confined to cool, high elevation (>800 m) rainforest and adjacent tall wet *E. andrewsii* ssp. *campanulata* [now *E. campanulata*] and *E. grandis* / *E. saligna* / *L. confertus* forest with *Banksia* understorey in south-east Qld. Whether the species inhabits drier and lower elevation forest communities, as well as heathland and *Banksia* woodland, in south-east Qld should be the subject of future field studies. Such work should also seek to document the edge of this species' range, and also to study the mechanisms that limit the distribution of *C. nanus*. Understanding of geographic range limits are, after all, a point of entry into understanding the ecological niche and threshold responses of species to environmental change (Caughley *et al.* 1988; Hoffman and Blows 1994; Brown

et al. 1996; Holt and Keitt 2005; Parmesan *et al.* 2005). Furthermore, this species may be vulnerable to climate change and, therefore, understanding its ecology or use of habitat at the northern extreme of its range is likely to provide insight to its conservation when global warming becomes more pronounced.

Conservation Status

Most of the modern *C. nanus* records for Qld are from protected areas (i.e. Lamington and Mt Barney NPs). However, the species' future conservation may not be guaranteed since *C. nanus* is at the edge of its range in Qld. Peripheral populations are likely to be smaller than central populations and also more prone to extirpation due to stochastic or catastrophic demographic or environmental events (see Lesica and Allendorf 1995). Also, peripheral populations may be genetically distinct from other populations through adaptation to different local conditions and may be of significant importance in conservation. Therefore, not only will these populations require a particular focus from conservation managers but also they may require more resources or effort to secure. Furthermore, *C. nanus* is likely to be sensitive to several threatening processes (e.g. inappropriate fire regimes, introduced predators and climate change). This was recognised when the species was listed as 'Vulnerable' in NSW and SA (Bowen and Goldingay 2000; van Weenen and Harris 2006).

Available data indicate that *C. nanus* meets the criteria for 'endangered' on the basis of the species' highly restricted range in Qld. However, in contrast to the situation in NSW and Victoria, targeted survey effort in this State has been limited. The potential exists for discoveries of *C. nanus* to be made north-west of Mt Barney NP, within areas of Main Range NP that are predicted to have 'High' suitability habitat (Fig. 1). The possibility also remains that *C. nanus* occupies heathland and *Banksia* woodland in the Granite Belt of south-east Qld (e.g. sections of Girraween NP), given the species' preference for such habitats elsewhere in its range (Ward 1990; Turner and Ward 1995; Bowen and Goldingay 2000; Harris and Goldingay 2005a; van Weenen and Harris 2006). Any additional records from such areas would increase estimates of both the extent of occurrence and area of occupancy for the species in this State, perhaps taking them over the threshold values provided under criterion B for the 'endangered' category. Nevertheless, where uncertainty exists, IUCN guidelines clearly indicate that assessments of conservation status for particular taxa should be based upon the evidence at hand (Species Survival Commission 2001). Until other populations are identified in this State and it can be demonstrated that the species has a larger geographic range than we have indicated, the precautionary approach dictates that an 'endangered' listing for *C. nanus* should stand.

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APPENDIX 1

Appendix 1: Records of the Eastern Pygmy-possum *Cercartetus nanus* in Queensland listed in order of age. Sources: WN = WildNet database record, QM = Queensland Museum record, with specimen number is parentheses. Abbreviations: NP = National Park. (Map datum for records: GDA94)

Date	Locality	Sources	Latitude (S)	Longitude (E)	Altitude (m)
Late Pleistocene	Russenden Cave, Viator Hill, near Texas	Archer 1978a, QM (F8207), WN	28.9342	151.4558	399
Late Pleistocene	Russenden Cave, Viator Hill, near Texas	Archer 1978a, QM (F8209)	28.9342	151.4558	399
Pre-Jan 1936	O'Reilly's Rainforest Guesthouse, Lamington NP	QM (J5861), O'Reilly 1941, Wakefield 1970	28.2317	153.1372	922
Jan 1966	Main Border Track, 0.4 km south-east of O'Reilly's Rainforest Guesthouse, Lamington NP	QM (J13580), Fleay 1966a, Wakefield 1970, WN	28.2337	153.1398	923
31 Mar 1966	Nagarigoon Camp, 3.0 km south-east of Binna Burra Mountain Lodge, Lamington NP	Anon. 1966, Fleay 1966b, P. Ogilvie pers. comm., WN	28.2184	153.2014	750
Jan 1977	Lamington NP Road, 1.5 km north-west of O'Reilly's Rainforest Guesthouse, Lamington NP	Winsor 1980, P. O'Reilly pers. comm., WN	28.2221	153.1251	926
19 Dec 1977	Lightning Falls Circuit near Echo Point, Lamington NP	QM (JM2331)	28.2734	153.1677	950
21 Mar 1981	Running Creek valley, west of Lamington NP boundary	QM (JM9715)	28.3317	153.0177	359
Sep 1981	Main Border Track near Mt Merino, Lamington NP	QM (JM3612)	28.2475	153.1884	1152
1988-1992	Wishing Tree Track near O'Reilly's Rainforest Guesthouse, adjacent to Lamington NP	T. O'Reilly pers. comm., WN	28.2353	153.1347	814
20 Aug 1992	Main Border Track, 4.1 km south-east of O'Reilly's Rainforest Guesthouse, Lamington NP	QM (JM9549), WN	28.2590	153.1622	1086
15 Sep 1994	Ridgeline, 1.5 km south-west of Mt Ballow, Mount Barney NP	G. Krieger pers. comm., WN	28.2859	152.5955	793
18-20 Nov 1994	Track to Tree Top Walk near O'Reilly's Rainforest Guesthouse, adjacent to Lamington NP	E. Meyer pers. comm. 2005 (UQ), WN	28.2323	153.1377	923
6 Sep 1995	Ridgeline, 0.6 km north-west of Montserrat Lookout, Mt Barney NP	QM (JM16948), G. Krieger pers. comm., WN	28.2601	152.6430	927
21 Jan 2002	Lyrebird Lookout Track just east of Moran's Creek crossing, Lamington NP	QM (JM15007), WN	28.2456	153.1447	999

APPENDIX 2

Appendix 2: Habitat suitability for *Cercartetus nanus* of regional ecosystems above 750 m in south-east Qld. Abbreviations: RE = Regional Ecosystem code; NP = National Park

RE	Regional Ecosystem Description	Suitability Score	Rationale
12.8.1	*Eucalyptus campanulata* tall open forest with shrubby to grassy understorey on Cainozoic igneous rocks	High	Shrub understorey present; occurs at high altitude in Lamington and Mt Barney NPs, often adjacent to rainforest; known *C. nanus* records in this RE (Mt Barney NP)
12.8.4	Complex notophyll vine forest with *Araucaria* spp. on Cainozoic igneous rocks	High	Known *C. nanus* records in this RE (Lamington NP)
12.8.5	Complex notophyll vine forest on Cainozoic igneous rocks. Altitude usually >600m	High	Known *C. nanus* records in this RE (Lamington NP, Mt Barney NP)
12.8.6	Simple microphyll fern forest with *Nothofagus moorei* on Cainozoic igneous rocks	High	Known *C. nanus* records in this RE (Lamington NP)
12.8.9	*Lophostemon confertus* open forest often with vine forest understorey ('wet sclerophyll') on Cainozoic igneous rocks	High	Known *C. nanus* records in this RE (Mt Barney NP)
12.8.2	*E. oreades* tall open forest on Cainozoic igneous rocks	Medium	Shrub understorey present; occurs at high altitude adjacent to *C. nanus* localities but no known records
12.8.7	Simple microphyll fern thicket with *Acmena smithii* on Cainozoic igneous rocks	Medium	Occurs at high elevation, probably close to 12.8.6 but no known records
12.8.8	*E. saligna* or *E. grandis* tall open forest on Cainozoic igneous rocks	Medium	Shrub understorey and adjacent to rainforest but no known records
12.8.8a	*E. siderophloia, E. microcorys, E. propinqua, Corymbia intermedia E. carnea* open forest on Cainozoic igneous rocks. Occurs on Cainozoic igneous rocks and areas subject to local enrichment from Cainozoic igneous rocks.	Medium	Similar to 12.8.8; no known *C. nanus* records
12.8.11	*E. dunnii* tall open forest on Cainozoic igneous rocks	Medium	Occurs close to rainforest edges; often has suitable shrub plus *Xanthorrhoea* understorey; no known records
12.8.14	*E. eugenioides, E. biturbinata, E. melliodora* open forest on Cainozoic igneous rocks	Medium	Often adjacent to rainforest but no known records
12.8.18	Simple notophyll vine forest with *Ceratopetalum apetalum* on Cainozoic igneous rocks	Medium	Occurs adjacent to *C. nanus* localities at Lamington NP but no known records
12.8.19	Montane shrubland on Cainozoic igneous rocks	Medium	Dominant shrub understorey but no known records
12.8.20	Shrubby woodland with *E. racemosa* or *E. dura* on Cainozoic igneous rocks	Medium	Shrub woodland is preferred by *C. nanus* in other areas of range but this is drier; no known records
12.11.1	Simple notophyll vine forest often with abundant *Archontophoenix cunninghamiana* (gully vine forest)	Medium	Other vine forest types are suitable but no known *C. nanus* records
12.11.3	Open forest generally with *E. siderophloia, E. propinqua* on metamorphics interbedded volcanics	Medium	Similar to 12.8.1 but drier, with reduced shrub understorey; no known records
13.3.2	*E. nova-anglica* open forest on alluvial plains	Medium	Shrub understorey; occurs at high altitude but no known records (occurs in Girraween NP)
13.12.1	*E. campanulata* open forest on igneous rocks	Medium	Similar to 12.8.1, including shrub understorey, but no known *C. nanus* records (occurs in Girraween NP)

APPENDIX 2

RE	Regional Ecosystem Description	Suitability Score	Rationale
13.12.2	*E. andrewsii, E. youmanii* woodland on igneous rocks	Medium	Similar to 12.8.1, including shrub understorey, but no known *C. nanus* records (occurs in Girraween NP)
13.12.3	*E. scoparia* woodland on igneous rocks	Medium	Similar to 12.8.1, including shrub understorey, but no known *C. nanus* records (occurs in Girraween NP)
13.12.6	Shrubland on igneous rocks	Medium	Dominant shrub understorey, but no known records (occurs in Girraween NP)
13.12.9	*E. blakelyi* and/or *E. caliginosa* woodland to open forest on igneous rocks	Medium	Shrub understorey, but no known records (occurs in Girraween NP)
11.3.23	*E. conica, E. nobilis, E. tereticornis, Angophora floribunda* on alluvial plains. Basalt derived soils	Low	Not known as suitable habitat anywhere within *C. nanus* range.
11.8.2	*E. tereticornis, E. melliodora* woodland on Cainozoic igneous rocks	Low	Not known as suitable habitat anywhere within *C. nanus* range; limited extent
11.8.3	Semi-evergreen vine thicket on Cainozoic igneous rocks.	Low	Vine thicket not known as suitable habitat anywhere within *C. nanus* range
11.8.5	*E. orgadophila* grassy open woodland on Cainozoic igneous rocks	Low	Grassy woodland not known as suitable habitat anywhere within *C. nanus* range
11.8.5a	*E. orgadophila* grassy open woodland on Cainozoic igneous rocks	Low	Grassy woodland not known as suitable habitat anywhere within *C. nanus* range
11.8.8	*E. albens, E. crebra* grassy woodland on Cainozoic igneous rocks.	Low	Grassy woodland not known as suitable habitat anywhere within *C. nanus* range
11.9.4	Semi-evergreen vine thicket or *Acacia harpophylla* with a semi-evergreen vine thicket understorey on sedimentary rocks	Low	Vine thicket not known as suitable habitat anywhere within *C. nanus* range
11.9.13	*E. moluccana* or *E. microcarpa* open forest on fine-grained sedimentary rocks	Low	Lacks shrub understorey; not known as suitable habitat anywhere within *C. nanus* range
12.3.3	*E. grandis* tall open forest on alluvial plains	Low	Lacks shrub understorey; not known as suitable habitat anywhere within *C. nanus* range
12.3.7	*E. tereticornis, Callistemon viminalis, Casuarina cunninghamiana* fringing forest	Low	Not known as suitable habitat anywhere within *C. nanus* range; limited extent
12.3.9	*E. nobilis* open forest on alluvial plains	Low	Lacks shrub understorey; not known as suitable habitat anywhere within *C. nanus* range
12.8.10	*E. laevopinea* tall open forest on Cainozoic igneous rocks	Low	Lacks shrub understorey; limited extent
12.8.12	*E. obliqua* tall open forest on Cainozoic igneous rocks	Low	Not known as suitable habitat anywhere within *C. nanus* range; limited extent
12.8.13	Araucarian complex microphyll vine forest on Cainozoic igneous rocks	Low	Drier end of rainforest spectrum; not known as suitable habitat anywhere within *C. nanus* range

APPENDIX 2

RE	Regional Ecosystem Description	Suitability Score	Rationale
12.8.15	*Poa labillardieri* grassland on Cainozoic igneous rocks	Low	Grassland not known as suitable habitat anywhere within *C. nanus* range
12.8.16	*E. crebra, E. tereticornis* woodland on Cainozoic igneous rocks	Low	Lacks shrub understorey; dry forest
12.8.17	*E. crebra, E. melanophloia* woodland on Cainozoic igneous rocks	Low	Lacks shrub understorey; dry forest
12.8.21	Semi-evergreen vine thicket with *Brachychiton rupestris* on Cainozoic igneous rocks.	Low	Vine thicket not known as suitable habitat anywhere within *C. nanus* range
12.8.23	*Acacia harpophylla* open forest on Cainozoic igneous rocks	Low	Brigalow not known as suitable habitat anywhere within *C. nanus* range
12.8.24	*Corymbia citriodora* open forest on Cainozoic igneous rocks especially trachyte	Low	Lacks shrub understorey; dry forest
12.8.25	Open forest with *E. acmenoides* or *E. helidonica* on Cainozoic igneous rocks especially trachyte	Low	Lacks shrub understorey; not known as suitable habitat anywhere within *C. nanus* range
12.9-10.5	Open forest complex often with *Corymbia trachyphloia, C. citriodora, E. crebra, E. fibrosa subsp. fibrosa* on quartzose sandstone	Low	Shrub understorey but dry forest
12.9-10.7	*Eucalyptus crebra* woodland on sedimentary rocks	Low	Shrub understorey but dry forest
12.9-10.15	Semi-evergreen vine thicket with *Brachychiton rupestris* on sedimentary rocks	Low	Vine thicket not known as suitable habitat anywhere within *C. nanus* range
12.9-10.16	Araucarian microphyll to notophyll vine forest on sedimentary rocks	Low	Drier end of rainforest spectrum; not known as suitable habitat anywhere within *C. nanus* range
12.9-10.17	Open forest complex often with *E. acmenoides, E. major, E. siderophloia Corymbia citriodora* on sedimentary rocks	Low	Shrub understorey but dry forest
12.11.10	Notophyll vine forest *Araucaria cunninghamii* on metamorphics interbedded volcanics	Low	Drier end of rainforest spectrum; not known as suitable habitat anywhere within *C. nanus* range
13.11.1	*E. youmanii, E. dealbata, E. caleyi, Callitris endlicheri* woodland on metamorphics	Low	Shrub understorey but dry forest; not known as suitable habitat anywhere within *C. nanus* range (occurs in Sundown NP)
13.11.2	*E. laevopinea* open forest on metamorphics	Low	Lacks shrub understorey; not known as suitable habitat anywhere within *C. nanus* range (occurs in Sundown NP)
13.11.3	*E. crebra* woodland on metamorphics	Low	Grassy woodland not known as suitable habitat anywhere within *C. nanus* range
13.11.4	*E. melanophloia* woodland on metamorphics	Low	Grassy woodland not known as suitable habitat anywhere within *C. nanus* range
13.11.5	*E. sideroxylon, E. fibrosa subsp. nubila* shrubby open forest on metamorphics	Low	Shrub understorey but dry forest
13.11.6	*Corymbia citriodora* open forest on metamorphics	Low	Lacks shrub understorey; dry forest

APPENDIX 2

RE	Regional Ecosystem Description	Suitability Score	Rationale
13.11.7	Low microphyll vine forest on metamorphics	Low	Drier end of rainforest spectrum; not known as suitable habitat anywhere within *C. nanus* range
13.11.8	*E. melliodora* and/or *E. microcarpa*/ *E. moluccana* woodland on metamorphics	Low	Shrub understorey but dry forest
13.12.4	*E. caliginosa, E. tereticornis* open forest on igneous rocks	Low	Lacks shrub understorey; dry forest
13.12.5	*E. youmanii* shrubby woodland on igneous rocks	Low	Shrub understorey but dry forest
13.12.8	*E. melliodora* and/or *E. moluccana*/ *E. microcarpa* and/or *E. conica* woodland on igneous rocks	Low	Shrub understorey but dry forest
13.12.10	*E. crebra, E. tereticornis, Angophora leiocarpa* woodland on igneous rocks	Low	Lacks shrub understorey; dry forest
13.3.1	*E. blakelyi* woodland on alluvial plains	Low	Lacks shrub understorey; dry woodland or forest
13.3.3	*E. nobilis* open forest on alluvial plains	Low	Not known as suitable habitat anywhere within *C. nanus* range
13.3.4	*E. conica, E. microcarpa, E. melliodora* woodland on alluvial plains	Low	Grassy woodland not known as suitable habitat anywhere within *C. nanus* range
13.3.6	Sedgeland on igneous rocks	Low	Not known as suitable habitat anywhere within *C. nanus* range
13.9.2	*E. moluccana* open forest on fine-grained sedimentary rocks	Low	Not known as suitable habitat anywhere within *C. nanus* range